



THURBER ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION REPORT
DUNC LAKE CULVERT REPLACEMENT
HIGHWAY 17, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 48.718928°, LONGITUDE: -85.689204°**

G.W.P. 6810-14-00, W.P. 6810-14-01, SITE No. 48E-047/C

GEOCRES Number: 42C-45

Report

to

HATCH

Date: December 18, 2018
File: 15595



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1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design of the proposed Dunc Lake Culvert replacement. The Dunc Lake Culvert is located on Highway 17, west of the town of White River, in the Unsurveyed District of Thunder Bay, Ontario. Thurber previously completed a preliminary foundation investigation at the culvert site in 2017.

The purpose of this investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch to carry out this detailed foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0008.

The preliminary investigation previously conducted by Thurber is described in the following report:

- Preliminary Foundation Investigation and Design Report, Dunc Lake Culvert Replacement, Highway 17, Unsurveyed Territory, Thunder Bay District, Ontario, GEOCRES Number 42C-44, prepared by Thurber Engineering Ltd.

The borehole logs from the preliminary investigation are included in this report.

2. SITE DESCRIPTION

The site is located along Highway 17, approximately 38 km west of the town of White River, Ontario. Highway 17 generally runs in an east-west direction at the culvert site. The existing culvert allows water from Dunc Lake to flow from north to south under Highway 17.

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Based on the Ontario Structure Inspection Manual (OSIM) prepared by MTO on November 20, 2014 the existing culvert is a structural plate corrugated steel pipe arch that is 3.7 m wide, 2.4 m high and 29.1 m long. The culvert barrel is in fair condition with light rusting of the bottom 200 mm of the CSP and rusting bolts.

The estimated culvert invert is at approximate Elevation 324.1 m at the inlet (north) and 324.0 m at the outlet (south). The existing road grade at the culvert location is at approximate Elevation 327.7 m. The height of fill above the culvert is approximately 1.0 m. The water level within Dunc Lake to the north and south of the culvert on October 4, 2015 was reported at Elevation 325.1 m. Photographs in Appendix D show the culvert and the surrounding area.

The site lies within the physiographic region known as the Wawa Subprovince of the Superior Province of the Canadian Shield. Based on OGS Map MRD126-Revision 1, titled "1:250,000 Scale Bedrock Geology of Ontario", dated 2011, the bedrock is of the Neo- to Mesoarchean age and consists of metasedimentary rocks, including wacke, siltstone and arkose. Based on OGS Map 2681, titled "Quaternary Geology of the Cedar Lake Area, Northern Ontario", dated 2009, the subsoils on site generally consist of a bedrock-drift complex (thin stratified veneer with numerous outcrops).

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between June 26 and 27, 2018, and consisted of drilling and sampling two (2) boreholes, designated as Boreholes 18-23 and 18-24, to depths of 8.1 m and 11.1 m, respectively. Both boreholes were drilled within the paved portion of Highway 17 at locations of proposed temporary modular bridge abutments.

The previous preliminary investigation was carried out between July 13, and September 10, 2017, during which time six boreholes denoted as Boreholes 17-01 to 17-06 were advanced to depths of between 1.7 and 9.9 m.

The Record of Borehole sheets for the boreholes from the current and previous preliminary investigations are included in Appendix A. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix C.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from topographic drawings provided to Thurber by Hatch. The



boreholes from the current investigation were drilling using a track-mounted CME 55 drill rig using wash boring techniques. In all boreholes, soil samples were obtained at selected intervals using a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT), or from auger cuttings for surficial material.

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. Boreholes were backfilled in general accordance with Ontario regulation 903, as amended by Regulation 128/03. A piezometer was installed as part of the preliminary investigation in Borehole 17-03.

Details of the piezometer installations and borehole completion are summarized as follows:

| Borehole Number | Borehole Depth / Base Elevation (m) | Piezometer Tip Depth / Elevation (m) | Completion Details |
|------------------------|--|---|---|
| 18-23 | 8.1 / 319.6 | None Installed | Borehole backfilled with cuttings to 1.7 m, bentonite holeplug to 0.6 m, sand to 0.3 m, then asphalt cold patch to surface. |
| 18-24 | 11.1 / 316.5 | None Installed | Borehole backfilled with cuttings to 2.9 m, bentonite holeplug to 0.6 m, sand to 0.3 m, then asphalt cold patch to surface. |
| 17-01 | 6.2 / 318.1 | None Installed | Bentonite holeplug and caved material to surface |
| 17-02 | 7.3 / 317.0 | None Installed | Bentonite holeplug and caved material to surface |



| Borehole Number | Borehole Depth / Base Elevation (m) | Piezometer Tip Depth / Elevation (m) | Completion Details |
|-----------------|-------------------------------------|--------------------------------------|---|
| 17-03 | 9.9 / 317.8 | 9.8/317.9 | Sand from 9.9 to 7.7 m, bentonite holeplug to 0.1 m, then asphalt to surface |
| 17-03 (DCPT) | 1.4 / 326.3 | None Installed | Cuttings to 0.1 m then asphalt to surface |
| 17-04 | 1.8 / 325.8 | None Installed | Cuttings to 0.3 m, dry cement to 0.1m then asphalt to surface |
| 17-05 | 3.0 / 324.6 | None Installed | Cuttings to 2.7 m, dry cement to 0.1m then asphalt to surface |
| 17-06 | 1.7 / 325.9 | None Installed | Cuttings to 1.0 m, bentonite holeplug to 0.3 m, concrete to 0.1m, then asphalt to surface |

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve). Point load tests were conducted on bedrock cores. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the fill, and a sample of the surface water from the lake upstream of the existing culvert were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented in Appendix B.



5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes consisted of asphalt pavement underlain by sand and gravel fill and gravelly sand with rock fill, which were in turn underlain by a layer of native sand and silt, and metasedimentary bedrock. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 18-23, 18-24, and 17-03 to 17-06 were drilled through the paved portions of Highway 17 and encountered a 75 mm to 125 mm thick layer of asphalt at the surface of each of these holes.

5.2 Sand and Gravel Fill

Sand and gravel fill with trace silt was encountered below the asphalt in Boreholes 18-23, 18-24, and 17-03 to 17-06. The thickness of the sand and gravel fill ranged from 0.6 to 1.7 m. Borehole 17-04 was terminated within this layer at a depth of 1.8 m (Elev. 325.8 m).

SPT 'N' values within the sand and gravel fill ranged from 29 to 102 blows per 0.3 m of penetration was recorded, indicating a compact to very dense relative density. Measured moisture contents between 3 percent and 68 percent were measured in the fill (typically 3 to 23 percent).

The results of grain size distribution analyses carried out on selected samples of the sand and gravel fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:



| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 33 to 55 |
| Sand | 41 to 57 |
| Silt and Clay | 4 to 10 |

5.3 Gravelly Sand Fill with Rockfill

A layer of gravelly sand fill containing rock fill and trace silt was encountered below the sand and gravel fill in Boreholes 18-23, 18-24, 17-03, 17-05 and 17-06. The gravelly sand with rock fill layer extended to depths of 3.0 to 4.1 m (Elev. 324.7 to 323.6 m) and ranged from 2.3 to 2.7 m in thickness where fully penetrated. Boreholes 17-05 and 17-06 were terminated within this layer at depths of 3.0 and 1.7 m respectively (Elev. 324.6 and 325.9 m). A dynamic cone penetration test (17-03 DCPT) was terminated upon refusal at a depth of 1.4 m (Elev. 326.3 m), which is expected to have occurred on this rock fill layer.

SPT 'N' values recorded within the gravelly sand with rock fill ranged from 16 to greater than 50 blows per 0.3 m of penetration, indicating that the rock fill material is compact to very dense. Measured moisture contents between 5 percent and 18 percent were measured in this fill.

The results of grain size distribution analyses carried out on selected samples of the gravelly sand with rock fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B2 of Appendix B. The results of the grain size distribution analysis are summarized below:

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 28 to 33 |
| Sand | 58 to 60 |
| Silt and Clay | 9 to 12 |

5.4 Sand to Sandy Silt

A deposit of sand to sandy silt, ranging in composition from trace silt to silty and trace gravel to gravelly, and containing trace clay, underlaid the fill in Boreholes 18-23, 18-24 and 17-03, at depths of between 3.0 m to 4.1 m (Elevations 324.7 m to 323.6 m), and was the surface soil layer below 0.3 m of lake water in Boreholes 17-01 and 17-02. Organic and wood debris were also encountered near the surface in Boreholes 17-01 and 17-02. This sand layer had a thickness ranging from 2.4 to 4.9 m and extended to depths ranging from 3.2 m to 7.9 m (Elev. 322.3 to 319.9 m).



SPT 'N' values within the sand to sandy silt deposit ranged from 3 to over 100 blows per 0.3 m of penetration, indicating a very loose to dense consistency (typically compact to dense). Measured moisture contents within the sand to sandy silt deposit varied between 7 percent and 28 percent.

The results of grain size distribution analyses carried out on selected samples of the sand to sandy silt layer are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 of Appendix B. The results of the grain size distribution analyses are summarized below:

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 0 to 14 |
| Sand | 28 to 86 |
| Silt | 19 to 63 |
| Clay | 4 to 9 |
| Silt and Clay | 13 |

5.5 Cobbles and Gravel

A layer of cobbles and gravel was encountered in Boreholes 17-02 and 17-03 below the sand deposit at depths of 3.9 and 6.6 m (Elevation 320.4 and 321.1 m respectively). The layer was 0.1 to 0.4 m in thickness.

5.6 Bedrock

Metasedimentary bedrock was encountered in Boreholes 18-23, 18-24 and 17-01 to 17-03 at depths ranging from 3.2 to 7.9 m (Elevations 319.7 to 322.3). The bedrock was confirmed by coring 2.7 to 3.2 m in each borehole. The bedrock was generally described as fresh to slightly weathered, with occasional quartz veins. Boreholes 18-23, 18-24, and 17-01 to 17-03 were terminated within the bedrock at depths ranging from 6.2 to 11.1 m (Elev. 316.5 to 319.6 m).

Total Core Recovery (TCR) in the bedrock was 100% with Solid Core Recovery (SCR) ranging from 49% to 100%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 19% to 100%, indicating very poor to excellent quality (typically fair to excellent). Average unconfined compressive strengths (UCS) of the rock ranged between 90 MPa to greater than 250 MPa based on correlations with the point load tests (PLT), indicating that the rock was strong to extremely strong.



5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. A standpipe piezometer was installed at Borehole 17-03. The groundwater levels measured in the open boreholes and piezometer are summarized below:

| Borehole | Date | Water Level (m) | | Remark |
|----------|---------------|-----------------|-----------|----------------------|
| | | Depth | Elevation | |
| 18-23 | June 26, 2018 | Dry | - | Open borehole |
| 18-24 | June 27, 2018 | 2.8 | 324.8 | Open borehole |
| 17-03 | July 14, 2017 | 2.8 | 324.9 | Open borehole |
| | July 16, 2017 | 2.1 | 325.6 | Standpipe piezometer |
| 17-04 | July 13, 2017 | Dry | - | Open borehole |
| 17-05 | July 13, 2017 | 2.4 | 325.2 | Open borehole |
| 17-06 | July 13, 2017 | Dry | - | Open borehole |

The water level of Dunc Lake on October 4, 2015 was reported to be Elev. 325.1 m and was measured at Boreholes 17-01 and 17-02 to be Elev. 324.3 m on September 9 and 10, 2017.

The groundwater and lake levels above are short-term readings, and seasonal fluctuations are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the gravelly sand fill from Borehole 17-03 and a sample of the lake water were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

| Parameter | Units (Soil) | Units (Water) | Test Results | |
|-----------|-----------------|------------------|-------------------------------|--------------|
| | | | 17-03, SS#3, 2.4 m – 3.0 m | Dunc Lake |
| | | | (Gravelly Sand Fill) | (Lake Water) |
| Sulphide | mg/L | mg/L | <0.02 | <0.006 |



| Parameter | Units (Soil) | Units (Water) | Test Results | |
|----------------------------|-----------------|------------------|-------------------------------|--------------|
| | | | 17-03, SS#3, 2.4 m – 3.0 m | Dunc Lake |
| | | | (Gravelly Sand Fill) | (Lake Water) |
| Chloride | mg/L | mg/L | 310 | 38 |
| Sulphate | mg/L | mg/L | 96 | 1.8 |
| pH | No unit | No unit | 8.83 | 7.84 |
| Electrical Conductivity | µS/cm | µS/cm | 680 | 210 |
| Resistivity | Ohms.cm | Ohms.cm | 1470 | 4760 |
| Redox Potential | mV | mV | 245 | 291 |

7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

Downing Drilling of Hawkesbury, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the current investigation. The field investigation was supervised on a full-time basis by Mr. Ryan McCourt of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch. The coordinate system MTM NAD83 Zone 14 was used for these boreholes.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE | VISUAL IDENTIFICATION |
|----------------|--------------------|---|
| Boulders | Greater than 200mm | same |
| Cobbles | 75 to 200mm | same |
| Gravel | 4.75 to 75mm | 5 to 75mm |
| Sand | 0.075 to 4.75mm | Not visible particles to 5mm |
| Silt | 0.002 to 0.075mm | Non-plastic particles, not visible to the naked eye |
| Clay | Less than 0.002mm | Plastic particles, not visible to the naked eye |

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY | PROPORTION |
|---------------------------------|---------------|
| Trace or Occasional | Less than 10% |
| Some | 10 to 20% |
| Adjective (e.g. silty or sandy) | 20 to 35% |
| And (e.g. sand and gravel) | 35 to 50% |

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROXIMATE SPT ⁽¹⁾ 'N' VALUE |
|------------------|--------------------------------|--|
| Very Soft | 12 or less | Less than 2 |
| Soft | 12 to 25 | 2 to 4 |
| Firm | 25 to 50 | 4 to 8 |
| Stiff | 50 to 100 | 8 to 15 |
| Very Stiff | 100 to 200 | 15 to 30 |
| Hard | Greater than 200 | Greater than 30 |

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

| DESCRIPTIVE TERM | SPT "N" VALUE |
|------------------|-----------------|
| Very Loose | Less than 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | Greater than 50 |

5. LEGEND FOR RECORDS OF BOREHOLES

| | | | |
|---|---|--|------------------------|
| SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE | SS Split Spoon Sample | WS Wash Sample | AS Auger (Grab) Sample |
| | TW Thin Wall Shelby Tube Sample | TP Thin Wall Piston Sample | |
| | PH Sampler Advanced by Hydraulic Pressure | PM Sampler Advanced by Manual Pressure | |
| | WH Sampler Advanced by Self Static Weight | RC Rock Core | SC Soil Core |

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


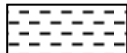



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

| MAJOR DIVISIONS | | GROUP SYMBOL | TYPICAL DESCRIPTION |
|----------------------|---------------------------------|--------------|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS | GW | Well-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GP | Poorly-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS | SW | Well-graded sands or gravelly sands, little or no fines. |
| | | SP | Poorly-graded sands or gravelly sands, little or no fines. |
| | | SM | Silty sands, sand-silt mixtures. |
| | | SC | Clayey sands, sand-clay mixtures. |
| FINE GRAINED SOILS | SILTS AND CLAYS $W_L < 50\%$ | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$). |
| | | CI | Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$). |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILTS AND CLAYS $W_L > 50\%$ | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of medium to high plasticity, organic silts. |
| HIGHLY ORGANIC SOILS | | Pt | Peat and other highly organic soils. |
| CLAY SHALE | | | |
| SANDSTONE | | | |
| SILTSTONE | | | |
| CLAYSTONE | | | |
| COAL | | | |

EXPLANATION OF ROCK LOGGING TERMS

| <u>ROCK WEATHERING CLASSIFICATION</u> | | <u>SYMBOLS</u> | |
|---------------------------------------|---|---|-------------------|
| Fresh (FR) | No visible signs of weathering. | | |
| Fresh Jointed (FJ) | Weathering limited to the surface of major discontinuities. |  | CLAYSTONE |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |  | SILTSTONE |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |  | SANDSTONE |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |  | COAL |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved. |  | Bedrock (general) |

| <u>DISCONTINUITY SPACING</u> | | <u>STRENGTH CLASSIFICATION</u> | | | |
|------------------------------|-----------------------|--------------------------------|---|---------------------|--|
| Bedding | Bedding Plane Spacing | Rock Strength | Approximate Uniaxial Compressive Strength | | Field Estimation of Hardness* |
| | | | (MPa) | (psi) | |
| Very thickly bedded | Greater than 2m | Extremely Strong | Greater than 250 | Greater than 36,000 | Specimen can only be chipped with a geological hammer |
| Thickly bedded | 0.6 to 2m | | | | |
| Medium bedded | 0.2 to 0.6m | Very Strong | 100-250 | 15,000 to 36,000 | Requires many blows of geological hammer to break |
| Thinly bedded | 60mm to 0.2m | | | | |
| Very thinly bedded | 20 to 60mm | Strong | 50-100 | 7,500 to 15,000 | Requires more than one blow of geological hammer to break |
| Laminated | 6 to 20mm | | | | |
| Thinly Laminated | Less than 6mm | Medium Strong | 25.0 to 50.0 | 3,500 to 7,500 | Breaks under single blow of geological hammer. |
| | | Weak | 5.0 to 25.0 | 750 to 3,500 | Can be peeled by a pocket knife with difficulty |
| | | Very Weak | 1.0 to 5.0 | 150 to 750 | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| | | Extremely Weak (Rock) | 0.25 to 1.0 | 35 to 150 | Indented by thumbnail |

| <u>TERMS</u> | |
|-------------------------------------|--|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. |
| Solid Core Recovery: (SCR) | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. |
| Rock Quality Designation: (RQD) | Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length. |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen |
| Fracture Index: (FI) | Frequency of natural fractures per 0.3m of core run. |

RECORD OF BOREHOLE No 18-23

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 663.0 E 401 280.2 ORIGINATED BY BRM
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/HQ Coring COMPILED BY MP
DATUM Geodetic DATE 2018.06.26 - 2018.06.26 LATITUDE 48.733164 LONGITUDE -100.342550 CHECKED BY MEF

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|--|--|--|---|--|---|---|---|----|--|----|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | WATER CONTENT (%) W _P W W _L | | | | GR | SA | SI | CL |
| 327.7 | GROUND SURFACE | | | | | | | | | | | | | | | | | | |
| 0.0 | ASPHALT (125mm) | | | | | | | | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL) | | 1 | SS | 102 | | | | | | | | | ○ | | | | 40 52 8 (SI+CL) | |
| 327.0 | | | | | | | | | | | | | | | | | | | |
| 0.7 | Gravelly SAND with ROCKFILL, trace silt Compact to Dense Brown Moist (FILL) | | 2 | SS | 23 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 3 | SS | 23 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 4 | SS | 39 | | | | | | | | | ○ | | | | | |
| 324.7 | | | | | | | | | | | | | | | | | | | |
| 3.0 | Silty SAND, some gravel, trace clay Dense Dark Brown to Grey Moist to Wet | | 5 | SS | 33 | | | | | | | | | ○ | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | 6 | SS | 35 | | | | | | | | | ○ | | | | 14 47 33 6 | |
| 322.3 | | | | | | | | | | | | | | | | | | | |
| 5.4 | BEDROCK: (Meta-Sedimentary), slightly weathered, bluish grey | | | | | | | | | | | | | | | | | | |
| | Sub vertical fracture 5.4m, 5.9m, 6.1m and 6.2m | | 1 | RUN | | | | | | | | | | | | | | RUN #1 TCR=100% SCR=49% RQD=36% UCS=>250MPa (Average) | |
| | Sub horizontal fracture at 5.6m | | | | | | | | | | | | | | | | | | |
| | Rubble zone from 5.6m to 7.1m | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | Mechanical fracture at 7.3m, 8.0m and 8.1m | | 2 | RUN | | | | | | | | | | | | | | RUN #2 TCR=100% SCR=97% RQD=87% UCS=>250MPa (Average) | |
| | Sub horizontal fracture at 7.9m | | | | | | | | | | | | | | | | | | |
| 319.6 | | | | | | | | | | | | | | | | | | | |
| 8.1 | END OF BOREHOLE AT 8.1m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 1.7m, BENTONITE HOLEPLUG TO 0.6m, SAND TO 0.3m, THEN COLD PATCH ASPHALT TO SURFACE. | | | | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-24

1 OF 2

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 679.4 E 401 247.8 ORIGINATED BY BRM
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/HQ Coring COMPILED BY MP
DATUM Geodetic DATE 2018.06.27 - 2018.06.27 LATITUDE 48.733306 LONGITUDE -100.342994 CHECKED BY MEF

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | | | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|---|---|--|--|--|--|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | | | |
| 327.6 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 0.0 | ASPHALT (100mm) | | | | | | | | | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL) | | 1 | SS | 76 | | 327 | | | | | | | | | | | | | |
| 326.9 | | | 2 | SS | 50/ | | | | | | | | | | | | | | | |
| 0.7 | Gravelly SAND with ROCK FILL, trace silt Compact to Very Dense Brown Moist (FILL) | | | | 0.075 | | | | | | | | | | | | | | | |
| | | | 3 | SS | 16 | | 326 | | | | | | | | | | | | | |
| | | | 4 | SS | 50/ | | | | | | | | | | | | | | | |
| | | | | | 0.050 | | 325 | | | | | | | | | | | | | |
| 324.6 | | | | | | | | | | | | | | | | | | | | |
| 3.0 | SAND, trace gravel Compact Brown Wet | | 5 | SS | 22 | | 324 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 323.0 | | | | | | | 323 | | | | | | | | | | | | | |
| 4.6 | Sandy SILT, trace clay Loose Grey Wet | | 6 | SS | 5 | | | | | | | | | | | | | | | |
| | | | | | | | 322 | | | | | | | | | | | | | |
| 321.5 | | | | | | | | | | | | | | | | | | | | |
| 6.1 | SAND, trace silt, trace clay, no gravel to gravelly Compact Grey Wet | | 7 | SS | 25 | | 321 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 320 | | | | | | | | | | | | | |
| 319.7 | | | 8 | SS | 50/ | | | | | | | | | | | | | | | |
| 7.9 | BEDROCK: (Meta-Sedimentary), fresh, very strong, bluish grey Mechanical fracture at 8.1m, 8.2m, 8.3m and 8.6m Sub horizontal fracture at 8.3m, 8.6m, 9.2m and 9.3m Sub vertical fracture at 8.5m and 9.2m Rubble zone (75mm) at 7.9m, 9.1m Horizontal fracture at 8.8m and 9.0m Sub horizontal fracture at 9.7m | | | | 0.100 | | 319 | | | | | | | | | | | | | |
| | | | 1 | RUN | | | | | | | | | | | | | | | | |
| | | | | | | | 318 | | | | | | | | | | | | | |

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-01

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 684.6 E 401 271.0 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE BW Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.09.10 - 2017.09.10 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | |
|---------------|---|------------|---------|------|---------------|----------------------------|-----------------|---|--|--|--|--|--|---|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | |
| 324.3 | GROUND SURFACE | | | | | | | <div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>20406080100</div> | | | | | <div>PLASTIC LIMIT</div> <div>NATURAL MOISTURE CONTENT</div> <div>LIQUID LIMIT</div> <div>W_P W W_L</div> <div>WATER CONTENT (%)</div> <div>204060</div> | | |
| 0.0 324.0 | WATER | | | | | | | | | | | | | | |
| 0.3 | SAND , some silt, trace clay, organic debris, wood fragments Loose to Dense Brown to Grey Wet Becoming silty Very Dense | | 1 | SS | 8 | | 324 | | | | | | | | |
| | | | 2 | SS | 34 | | 323 | | | | | | | | |
| | | | 3 | SS | 37 | | 322 | | | | | | | | |
| | | | 4 | SS | 111/ 0.178 | | | | | | | | | | |
| | | | 321.1 | | | | | | | | | | | | |
| 3.2 | BEDROCK: (Metasedimentary), occasional quartz veins, fresh, very strong, grey | | 1 | RUN | | | 321 | | | | | | | | |
| | | | 2 | RUN | | | | | | | | | | | |
| | | | 3 | RUN | | | | | | | | | | | |
| | | | 4 | RUN | | | | | | | | | | | |
| | | | 5 | RUN | | | | | | | | | | | |
| | | | 6 | RUN | | | | | | | | | | | |
| 318.1 | | | | | | | | | | | | | | | |
| 6.2 | END OF BOREHOLE AT 6.2m. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CAVED TO SURFACE. | | | | | | | | | | | | | | |

077194

RUN #1
TCR=100%
SCR=75%
RQD=31%
UCS=116MPa
RUN #2
TCR=100%
SCR=85%
RQD=71%
UCS=255MPa
RUN #3
TCR=100%
SCR=66%
RQD=66%
UCS=158MPa
RUN #4
TCR=100%
SCR=100%
RQD=100%
UCS=248MPa
RUN #5
TCR=100%
SCR=100%
RQD=19%
UCS=197MPa
RUN #6
TCR=100%
SCR=95%
UCS=204MPa

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/15/17

RECORD OF BOREHOLE No 17-02

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 660.3 E 401 253.8 ORIGINATED BY TY
HWY 17 BOREHOLE TYPE BW Coring COMPILED BY AN
DATUM Geodetic DATE 2017.09.07 - 2017.09.09 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| 324.3 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | |
| 0.0 | WATER | | | | | | | 20 | 40 | 60 | 80 | 100 | | |
| 324.0 | | | | | | | | | | | | | | |
| 0.3 | SAND , some silt, trace gravel, trace clay, organics and wood debris Compact Brown Wet | | 1 | SS | 13 | | 324 | | | | | | | |
| | | | 2 | SS | 19 | | 323 | | | | | | | |
| | Becoming gravelly | | 3 | SS | 10 | | 322 | | | | | | | |
| | Trace gravel | | 4 | SS | 14 | | 321 | | | | | | | |
| | | | 5 | SS | 3 | | | | | | | | | |
| | Becoming silty | | | | | | | | | | | | | |
| 320.4 | | | | | | | | | | | | | | |
| 3.9 | COBBLES and GRAVEL | | | | | | | | | | | | | |
| 320.0 | | | | | | | | | | | | | | |
| 4.3 | BEDROCK: (metasedimentary), occasional quartz veins, fresh, extremely strong, grey | | 1 | RUN | | | 320 | | | | | | | |
| | | | 2 | RUN | | | | | | | | | | |
| | | | 3 | RUN | | | 319 | | | | | | | |
| | | | 4 | RUN | | | | | | | | | | |
| | | | 5 | RUN | | | 318 | | | | | | | |
| 317.0 | | | | | | | | | | | | | | |
| 7.3 | END OF BOREHOLE AT 7.3m. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CAVED TO SURFACE. | | | | | | 317 | | | | | | | |
| | | | | | | | | | | | | | | |

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/15/17

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-03

1 OF 2

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 674.3 E 401 263.8 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.14 - 2017.07.14 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|--|--|--|--|---|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| 327.7 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.0 | ASPHALT: (100mm) | | | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt Compact Brown Damp (FILL) | | 1 | GS | | | 327 | | | | | | | |
| | | | 1 | SS | 29 | | | | | | | | | 33 57 10 (SI+CL) |
| 326.3 | | | | | | | | | | | | | | |
| 1.4 | Gravelly SAND with ROCKFILL, trace silt Very Dense to Dense Brown Damp to Wet (FILL) | | 2 | SS | 52/ 0.150 | | 326 | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 3 | SS | 48 | | 325 | | | | | | | |
| | | | 4 | SS | 47 | | | | | | | | | |
| | | | | | | | 324 | | | | | | | |
| 323.6 | | | | | | | | | | | | | | |
| 4.1 | SAND, fine grained, some silt to silty, trace gravel, trace clay Compact Grey to Brown Wet | | 5 | SS | 25 | | 323 | | | | | | | 0 76 20 4 |
| | | | | | | | | | | | | | | |
| | | | 6 | SS | 12 | | 322 | | | | | | | |
| | | | | | | | | | | | | | | |
| 321.1 | | | | | | | | | | | | | | |
| 320.0 | COBBLES and GRAVEL | | 1 | RUN | | | 321 | | | | | | | RUN #1 TCR=100% SCR=75% RQD=75% UCS=193MPa |
| 6.7 | BEDROCK: (metasedimentary), occasional quartz veins, fresh, very strong to strong, grey | | | | | | | | | | | | | |
| | Sub-vertical fracture (100mm) at 6.9m and (175mm) at 8.1m | | 2 | RUN | | | 320 | | | | | | | RUN #2 TCR=100% SCR=97% RQD=77% UCS=153MPa |
| | Sub-horizontal fracture (25mm) at 7.0m, 7.5m, 7.9m and 8.3m | | | | | | | | | | | | | |
| | Broken zone (50mm) at 8.0m Sub-horizontal fracture (25mm) at 8.4m and 9.5m | | | | | | | | | | | | | |
| | Sub-vertical fracture (50mm) at 9.2m, 9.5m, 9.7m and (175mm) at 9.8m | | 3 | RUN | | | 319 | | | | | | | RUN #3 TCR=100% SCR=97% RQD=82% UCS=90MPa |
| | Broken zone (50mm) at 9.3m and 9.7m | | | | | | | | | | | | | |
| 317.8 | | | | | | | 318 | | | | | | | |
| | | | | | | | | | | | | | | |

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-03

2 OF 2

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 674.3 E 401 263.8 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.14 - 2017.07.14 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|------------|-------------------------|-----------------|--|----|----|----|-----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 9.9 | Continued From Previous Page END OF BOREHOLE AT 9.9m. WATER LEVEL AT 2.8m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.16 2.1 325.6 2017.07.16 Decommissioned - | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 17-03 DCPT 1 OF 1 METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 674.3 E 401 263.8 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.14 - 2017.07.14 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|--|--|--|--|---|---------------------------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | |
| 327.7 | GROUND SURFACE | | | | | | | | | | | | | | |
| 0.0 | Auger to 0.4m and start DCPT | | | | | | | | | | | | | | |
| 327.3 | | | | | | | | | | | | | | | |
| 0.4 | DCPT start at 0.4m | | | | | | | | | | | | | | |
| | | | | | | | 327 | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 326.3 | | | | | | | | | | | | | | | |
| 1.4 | END OF DCPT AT 1.4m UPON REFUSAL. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | | |

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/15/17

RECORD OF BOREHOLE No 17-04

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 680.1 E 401 255.6 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.13 - 2017.07.13 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|--|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | |
| 327.6 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.0 0.1 | ASPHALT: (100mm) SAND and GRAVEL, trace silt Brown Damp (FILL) Possible rockfill from 0.8 to 1.8m | | 1 | GS | | | | | | | | | | | | 55 41 4 (SI+CL) | |
| 325.8 | | | | | | | | | | | | | | | | | |
| 1.8 | END OF BOREHOLE AT 1.8m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.3m, CEMENT TO 0.1m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 17-05

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 685.3 E 401 247.0 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.13 - 2017.07.13 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|----|----|----|-----|--|--|---|--|---------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) | | |
| 327.6 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | ASPHALT: (100mm) | | | | | | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt Brown Damp (FILL) | | 1 | GS | | | 327 | | | | | | | | | | |
| 326.4 | | | | | | | | | | | | | | | | | |
| 1.2 | Gravelly SAND with ROCKFILL, some silt Brown Damp to Moist (FILL) | | 2 | GS | | | 326 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 324.6 | | | | | | | 325 | | | | | | | | | | 28 60 12 (SI+CL) |
| 3.0 | END OF BOREHOLE AT 3.0m. BOREHOLE OPEN TO 1.5m AND WATER LEVEL AT 2.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 2.7m, CEMENT TO 0.1m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-06

1 OF 1

METRIC

W.P. 6810-14-01 LOCATION Dunc Lake Culvert, MTM NAD 83 Zone 14 N 5 398 691.1 E 401 238.9 ORIGINATED BY ES
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.13 - 2017.07.13 CHECKED BY NLB

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|----|----|----|--|---|---------------------------------------|---|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | |
| 327.6 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | |
| 0.0 | ASPHALT: (75mm) | | | | | | | | | | | | | | | |
| 0.2 | SAND and GRAVEL, trace silt Brown Damp (FILL) | | 1 | GS | | | 327 | | | | | | | | | 47 44 9 (SI+CL) |
| 326.5 | | | | | | | | | | | | | | | | |
| 1.1 | Gravelly SAND with ROCKFILL, trace silt Brown Moist (FILL) | | | | | | | | | | | | | | | |
| 325.9 | | | | | | | 326 | | | | | | | | | |
| 1.7 | END OF BOREHOLE AT 1.7m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 1.0m, BENTONITE HOLEPLUG TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | | | |

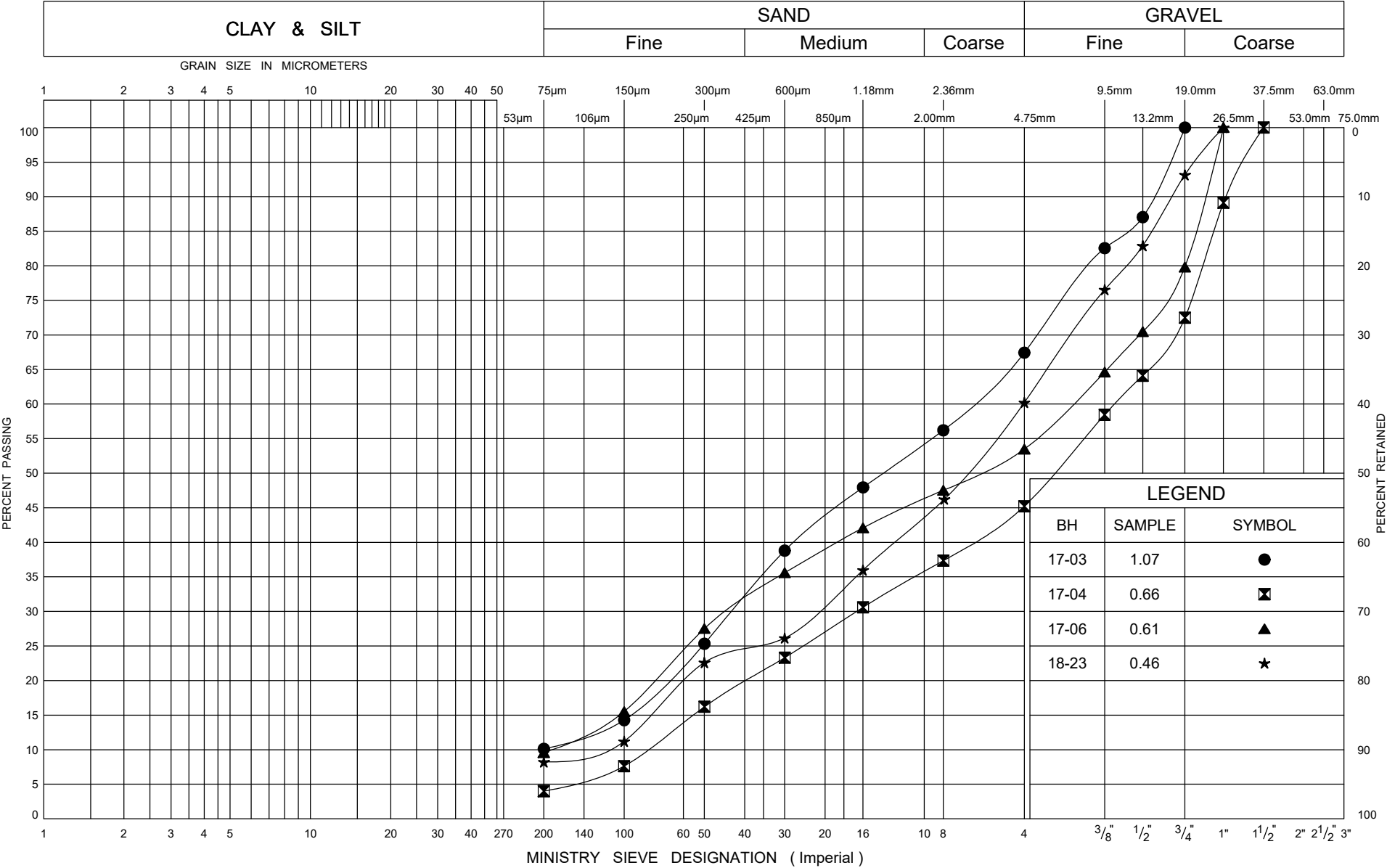
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Sensitivity

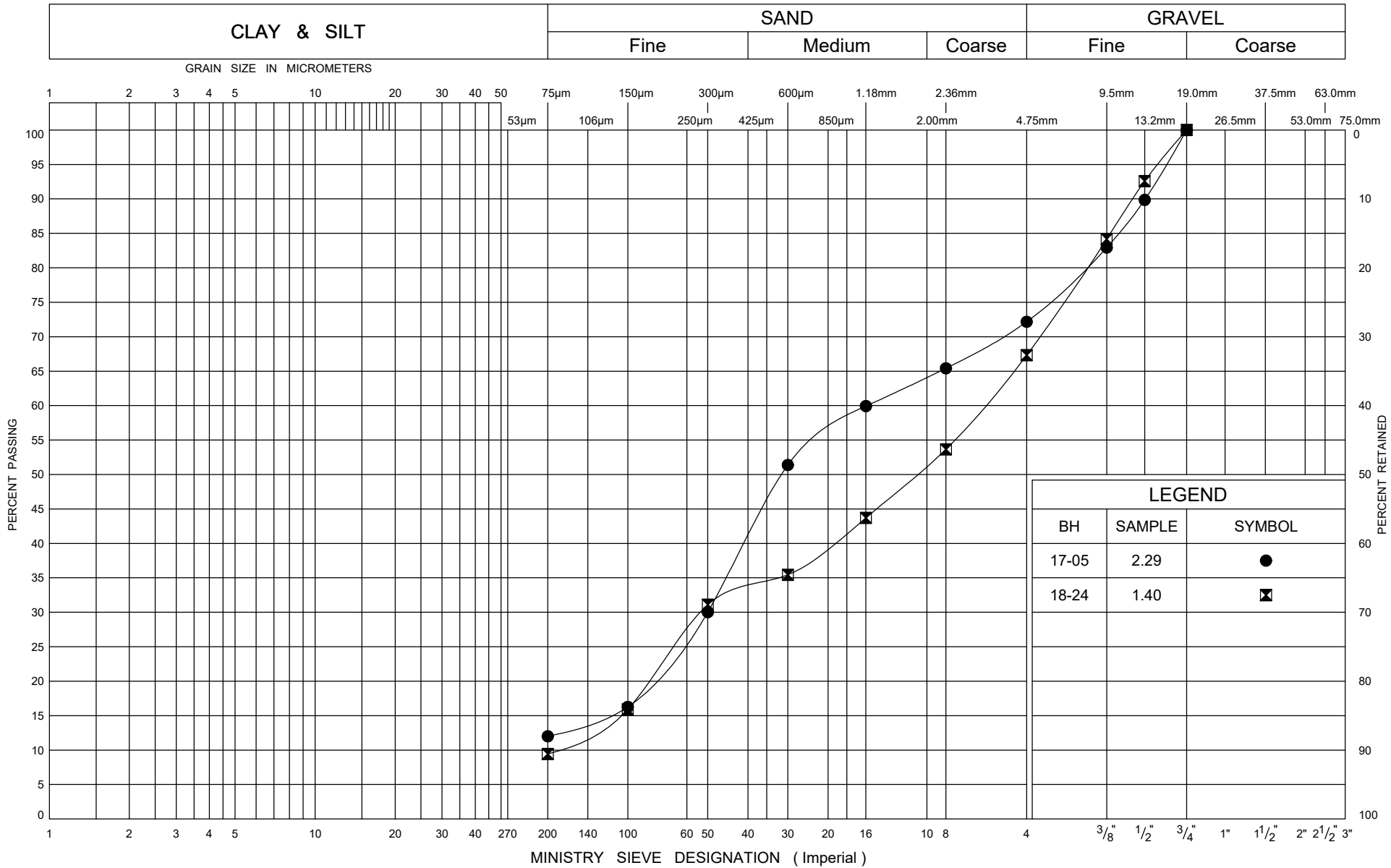
20
15
10
(%) STRAIN AT FAILURE

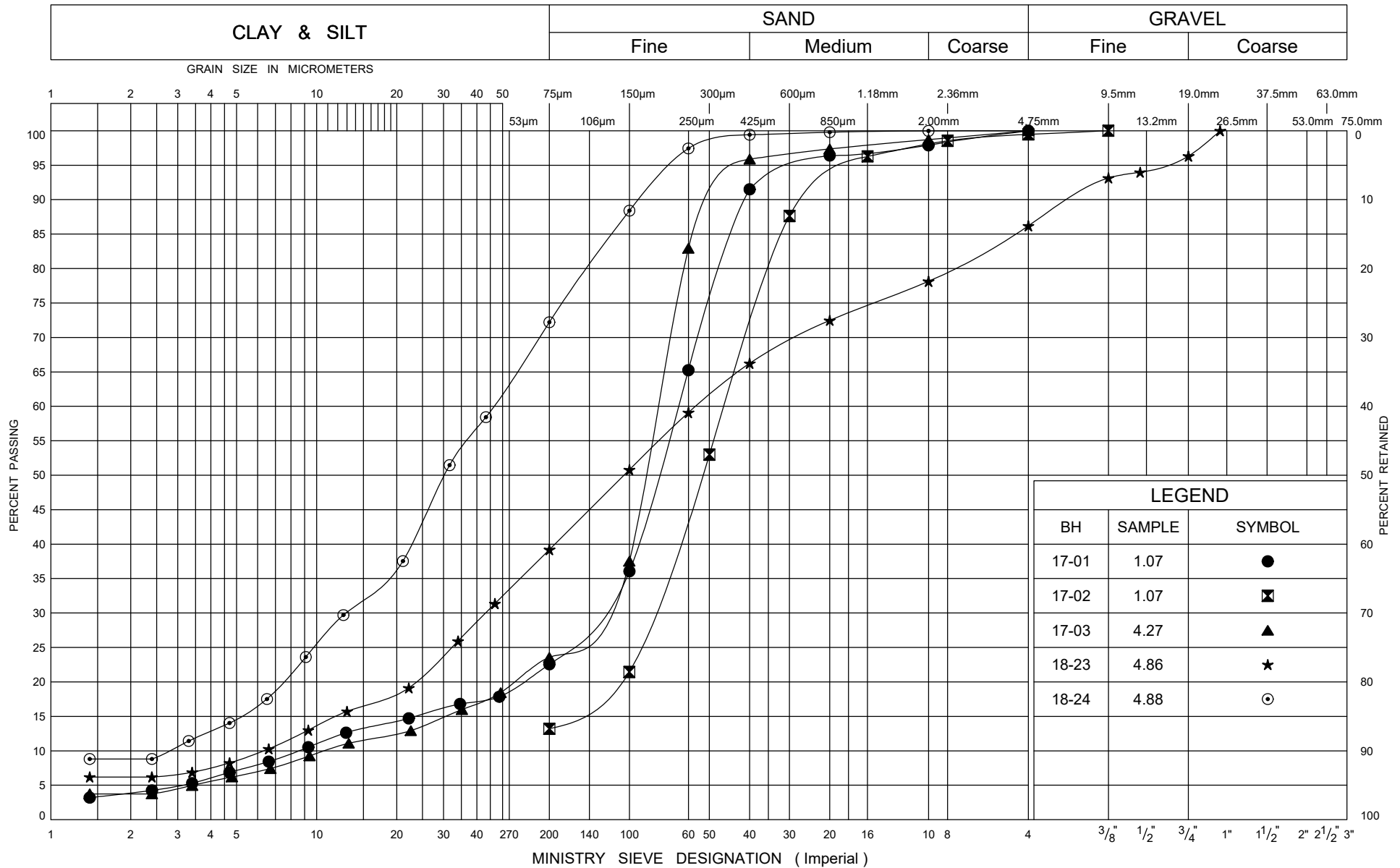


Appendix B

Laboratory Test Results







Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

SAND to Sandy SILT

FIG No B3

W P 6810-14-01

Dunc Lake Culvert



ASTM D5731-08

Date Drilled: June 27/18

Date Tested July 5/18

Tester: RT

Reviewed by MEF

[illegible]



ASTM D5731-08

| | |
|---------------|------------|
| Date Drilled: | June 27/18 |
| Date Tested: | July 5/18 |
| Tester: | RT |
| Reviewed by: | MEF |

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 15595

Client: HATCH

Project Name: Dunc Lake Culvert Replacement

| | | | |
|------------|----|---------|-------|
| Core Size: | NQ | BH No : | 17-01 |
|------------|----|---------|-------|

Date Drilled: Sep 19/17

Date Tested: Sep 25/17

Tester: GA

Reviewed by: WM

[illegible]



ASTM D5731-08

| | |
|---------------|-----------|
| Date Drilled: | Sep 8/17 |
| Date Tested: | Sep 25/17 |
| Tester: | GA |
| Reviewed by: | WM |

[illegible]

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 15595

Client: HATCH

Project Name: Dunc Lake Culvert Replacement

| | | | |
|------------|----|---------|-------|
| Core Size: | NQ | BH No : | 17-03 |
|------------|----|---------|-------|

Date Drilled: July 14/17

Date Tested: Sep 6/17

Tester: JZ

Reviewed by: WM

[illegible]

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Client
SGS LIMS Number
Analysis Package:

Attention: Mark Farrant
Project#: 15595
Thurber Engineering Ltd.
CA14253-SEP17
Corrosivity (Soil)

Sample ID Unit BH-3, SS#3, 8'-10'

Sample Date/Time 14-Jul-17

| | | |
|--------------------------|---------|-------|
| Moisture | % | 13.2 |
| pH | no unit | 8.83 |
| Corrosivity Index | none | 14.0 |
| Soil Redox Potential | mV | 245 |
| Sulphide | mg/L | <0.02 |
| Chloride | mg/L | 310.0 |
| Sulphate | mg/L | 96 |
| Conductivity | uS/cm | 680 |
| Resistivity (calculated) | ohms.cm | 1470 |

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

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(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Client
SGS LIMS Number
Analysis Package:

Attention: Mark Farrant
Project#: 15595
Thurber Engineering Ltd
CA13437-JUL17
Corrosivity

| Sample ID | Unit | Analysis Start Date | Analysis Approval Date | Dunc Lake Culvert |
|--------------------------|---------|---------------------|------------------------|-------------------|
| Sample Date/Time | | | | |
| Temperature Upon Receipt | °C | | | 21.0 |
| Corrosivity Index | NA | 01-Jun-17 | 01-Jun-17 | |
| Redox Potential | mV | 29-May-17 | 30-May-17 | 291 |
| Sulphide | mg/L | 01-Jun-17 | 01-Jun-17 | <0.006 |
| % Moisture (wet wt) | NA | 30-May-17 | 01-Jun-17 | |
| pH | units | 30-May-17 | 31-May-17 | 7.84 |
| Chloride | mg/L | 31-May-17 | 01-Jun-17 | 38.0 |
| Sulphate | mg/L | 31-May-17 | 01-Jun-17 | 1.8 |
| Conductivity | µS/cm | 30-May-17 | 31-May-17 | 210 |
| Resistivity (calculated) | ohms.cm | 30-May-17 | 01-Jun-17 | 4760 |

Corrosivity Index is based on the AWWA
Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

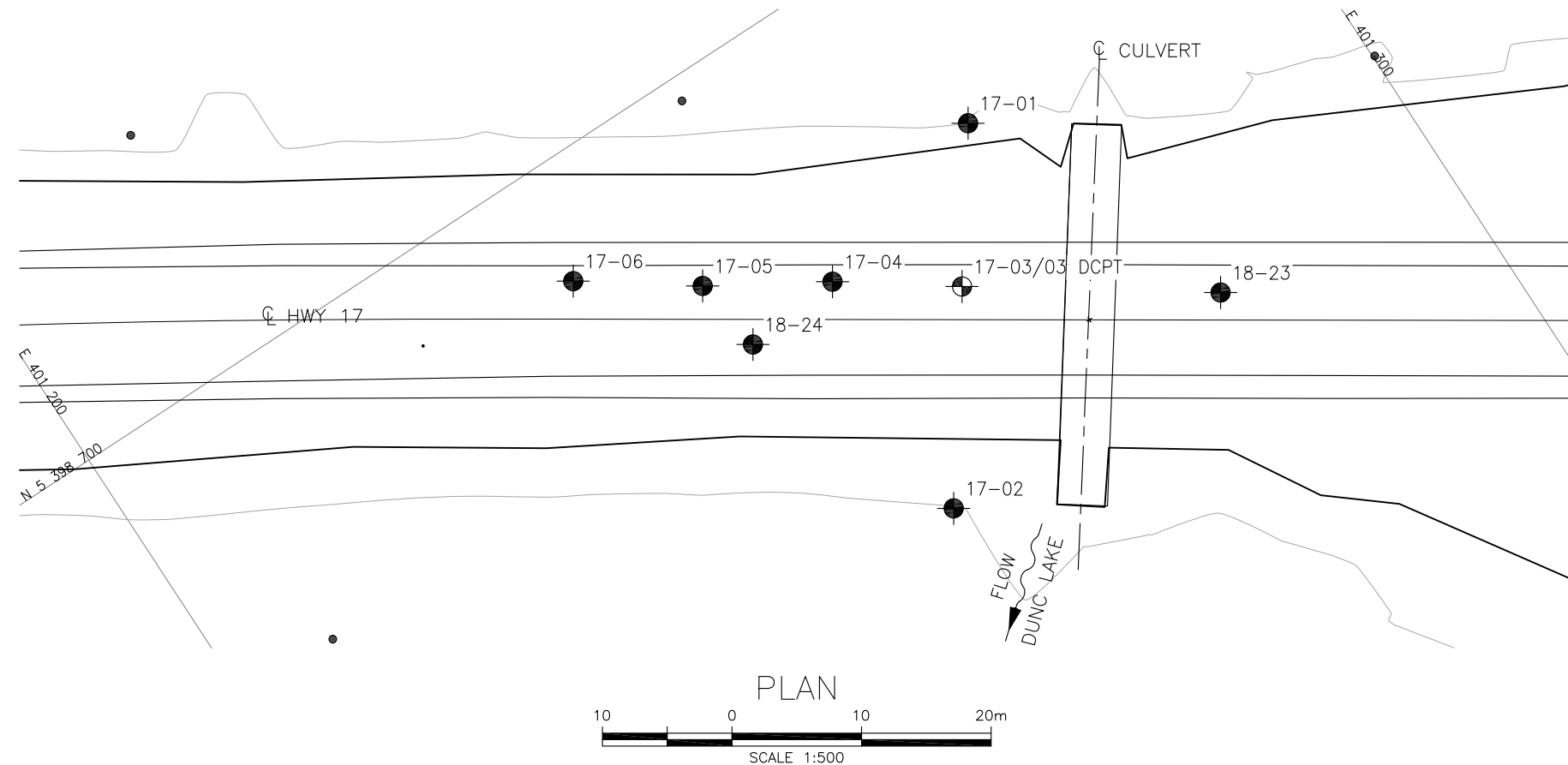
Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

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(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



Appendix C

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



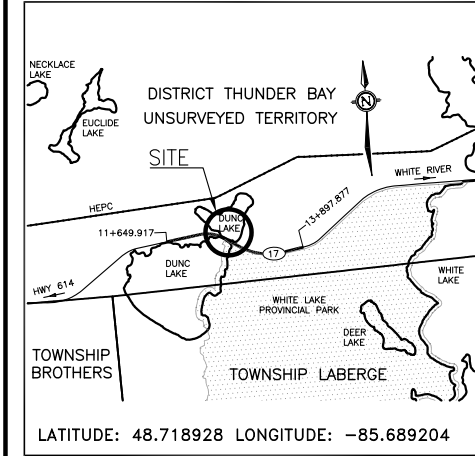
CONT No
WP No 6810-14-01

HIGHWAY 17
DUNC LAKE
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET

HATCH



KEYPLAN

LEGEND

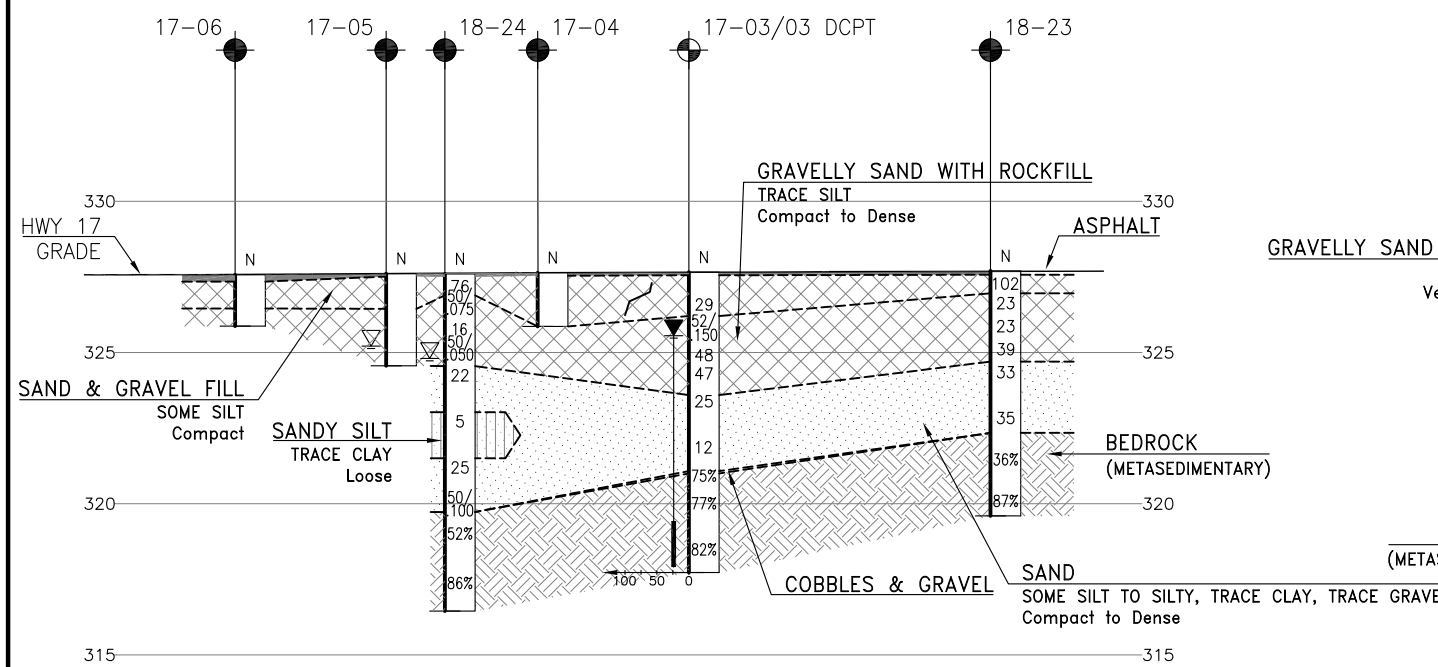
- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

| NO | ELEVATION | NORTHING | EASTING |
|---------------|-----------|-------------|-----------|
| 17-01 | 324.3 | 5 398 684.6 | 401 271.0 |
| 17-02 | 324.3 | 5 398 660.3 | 401 253.8 |
| 17-03/03 DCPT | 327.7 | 5 398 674.3 | 401 263.8 |
| 17-04 | 327.6 | 5 398 680.1 | 401 255.6 |
| 17-05 | 327.6 | 5 398 685.3 | 401 247.0 |
| 17-06 | 327.6 | 5 398 691.1 | 401 238.9 |
| 18-23 | 327.7 | 5 398 663.0 | 401 280.2 |
| 18-24 | 327.6 | 5 398 679.4 | 401 247.8 |

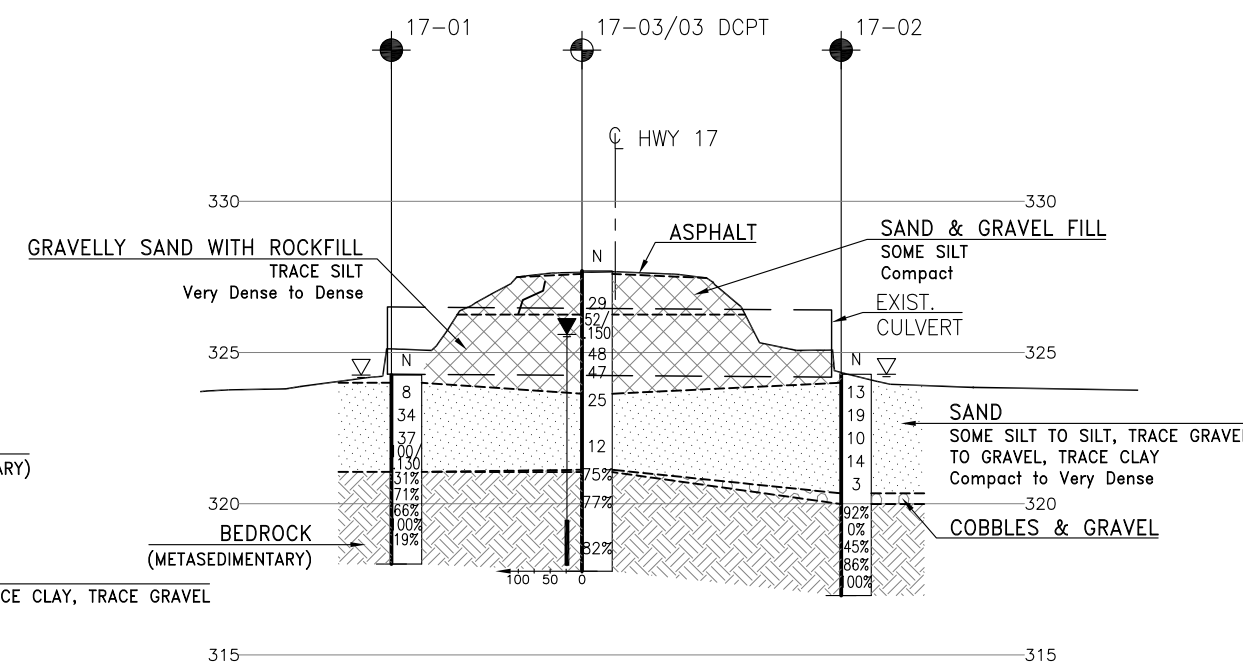
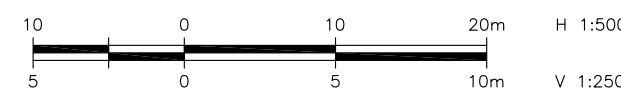
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No.



PROFILE ALONG Q HWY 17



SECTION ALONG Q CULVERT

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----------|-------------|
| DESIGN | NLB | CHK MEF | CODE |
| DRAWN | AN | CHK PKC | SITE |
| LOAD | DATE | DEC 2018 | |
| STRUCT | DWG | 1 | |



Appendix D

Site Photographs



Photo 1: Culvert inlet looking west (May 17, 2017)



Photo 2: Culvert inlet looking east (May 17, 2017)



Photo 3: Culvert outlet looking west (May 17, 2017)



Photo 4: Culvert outlet looking east (May 17, 2017)



Photo 5: Culvert inlet looking north (May 17, 2017)



Photo 6: Road approach looking west (May 17, 2017)



Photo 7: Road approach looking east (May 17, 2017)